DUAL DRIVE FOR HYDRAULIC PUMP AND AIR BOOST COMPRESSOR

INVENTORS
Howard Carter III
Richard N. Johnson
Michael John Provost
John David Brown

FIELD OF THE INVENTION

This invention relates generally to drive systems, and specifically to lightweight and efficient drive systems for aircraft subsystems, and any other vehicle with auxiliary systems.

BACKGROUND OF THE INVENTION

Bleed air from aircraft engines is commonly used to power hydraulic pumps utilized in aircraft subsystems, and especially for landing gear and flap hydraulic systems. Such pumps offer reliable, but inefficient, power transfer from bleed air into hydraulic flow and pressure. Expansion of bleed air through a turbine is limited to efficiencies between 50 to 70 percent, depending upon the bleed pressure available.

As aircraft engine designers have sought greater fuel efficiencies, engines have shifted towards higher compression ratios and higher fan bypass ratios to make the engines more fuel-efficient. However, such engines are more sensitive to bleeding air for aircraft subsystems. Thus, new airplane designs with advanced high bypass ratio engines cannot provide traditional support for engine bleed air extraction to power subsystems without a significant efficiency penalty.

This has led to the increased use of electric motor driven subsystems, often with separate motor drives. Different aircraft subsystems, including and commonly hydraulic

systems and air conditioning systems, have different power requirements, with power needed in different locations of the aircraft, at different times during the flight and on the ground. Often, due to the constraints of the subsystems, different speeds and torque are required. Multiple electric motor driven subsystems provide flexibility as to location, timing of operation, and velocity. However, for aircraft, multiple electric motor driven subsystems carry the detriment of increased weight.

Therefore, an unmet need exists for drive systems for auxiliary subsystems which reduce weight and size of subsystem drives, while allowing flexible power applicability and flexible rotational velocities for the different subsystems.

SUMMARY OF THE INVENTION

The present invention provides a drive system for two aircraft subsystems from a single power source.

The dual drive system of the present invention includes at least one reversible electric motor with a double-ended output shaft connected to two over-running clutches, in turn connected to two separate subsystem components. The over-running clutches are configured to engage alternately, with one clutch engaged when the motor runs in one direction, and the other clutch engaged when the motor is reversed.

In accordance with further aspects of the invention, the drive system is utilized in an aircraft, where one of the aircraft subsystems driven by the drive is a hydraulic pump, and the other is an air compressor. Other aspects of the invention include combining a gearing system with one or both of the over-running clutches to allow the respective subsystem components to be driven at different speeds.

In a further aspect of the invention, a second electric motor may be used to drive one of the aircraft subsystem components in addition to the reversible motor, thus providing power to that subsystem component even when the reversible motor is reversed and providing power to the alternate aircraft subsystem. The reversible motor may also have dual speeds, permitting rotation at one velocity when the motor is run in one direction and driving one aircraft subsystem, and rotation at a different velocity when the motor runs in the reverse direction driving the other subsystem.

The invention provides flexibility in powering equipment subsystems, especially aircraft hydraulic and air conditioning subsystems from a single motor, providing different output speeds for the respective subsystems from the same drive.

Brief Description of the Drawings

The preferred and alternative embodiments of the present invention are described in detail below with reference to the following drawing.

FIGURE 1 is a symbolic cross section of the dual drive for hydraulic pump and air boost compressor, with a second motor drive.

Detailed Description of the Invention

FIGURE 1 is a symbolic cross section of a dual drive system 5. The dual drive system 5 includes a reversible motor 10. In a presently preferred embodiment, the reversible motor is a dual speed electric motor. In an alternate embodiment, the reversible motor is a variable speed electric motor. The reversible motor 10 has a main shaft 12 with two ends. One end of the main shaft 12 is connected to a clockwise over running clutch 20, which freewheels in the clockwise direction, and engages in the counterclockwise direction. The clockwise over-running clutch has an output shaft 32. In a presently preferred embodiment, the clockwise over-running output clutch 32 is connected to and drives a hydraulic pump 30. The other end of the main shaft 12 is connected to a counter clockwise over-running clutch 22. The counter clockwise over-running clutch 22 freewheels in the counterclockwise direction and engages in the clockwise direction. In a preferred embodiment, the counterclockwise over-running clutch is connected to and drives an air compressor 40. In this embodiment, the air compressor is the first stage of a ram air compressor with a ram air inlet 42, and a ram air outlet 44. In alternate embodiments, the main shaft 12 may be an alternate driving connection, such as gear or spline outputs.

As can be seen from FIGURE 1, in connection with the clockwise and counterclockwise over-running clutches, the reversible motor 10 drives the hydraulic pump 30 when the main shaft 12 rotates counterclockwise, and drives the air compressor 40 when the main shaft 12 rotates in a clockwise direction. In a presently preferred embodiment, the drive motor 10 is a dual speed reversible electric motor providing a different main shaft 12 output speed when the motor runs in a clockwise direction than when the motor runs in a counterclockwise direction. Alternately, a variable speed reversible motor would provide equivalent multi-speed function, with greater power output flexibility. Also, in a presently preferred embodiment, the clockwise over-running clutch 20 is combined with a gear system (not shown) that reduces the speed of the clockwise over-running clutch output shaft 32 driving the hydraulic pump 30. In other embodiments of the current invention, different speed and different gearing systems may be linked to the clockwise over-running clutch 20 and/or the counterclockwise over-running clutch 22. In a presently

preferred embodiment, the gear system (not shown) combined with the clockwise over-running clutch 20 and driving the hydraulic pump 30 is a harmonic drive type of gear system.

FIGURE 1 shows an embodiment of the present invention with a second drive motor 60. The second drive motor 60 has an output shaft 62 in line with and, through intervening components, connected to the main shaft 12 of the reversible motor 10. In a presently preferred embodiment, the second drive motor shaft 62 is connected to and drives a second stage air compressor 50. The second stage air compressor 50 has a second stage inlet 52, and a second stage outlet 54. The second stage air compressor 50 is linked by a common shaft 64 to the air compressor 40. In an alternative embodiment, the second drive motor 10 through its drive shaft 62 may be connected directly to the air compressor 40. In a presently preferred embodiment, as shown in FIGURE 1, the air compressor 40, and the second stage air compressor 50 form part of an air cycle machine for air conditioning an aircraft. In a presently preferred embodiment, the common shaft 64 is a quill shaft link to the main shaft 12 through the air compressor 40.

In the embodiment shown in FIGURE 1, the second drive motor 60 is a nonreversible electric motor. When operating, the second drive motor 60 provides a base level of power to the air compressors 40 and 50 even when the reversible drive motor 10 is reversed and providing power to the hydraulic pump 30. Otherwise, both the reversible drive motor 10 and the second drive motor 60 provide combined power directly to the air compressors 40 and 50 while the hydraulic pump 30 is at rest, with the clockwise over-running clutch 20 freewheeling. In a presently preferred embodiment, as shown in FIGURE 1, when utilized in an aircraft, the second drive motor 60 runs constantly, providing a base level of air conditioning power through the two air turbine air compressors 40 and 50. For most of the on-ground and in-flight operational period for the aircraft, the reversible drive motor 10 provides power to the air conditioning system of the aircraft through air compressors 40 and 50. During periods when substantial hydraulic power is required, such as for raising and lowering the landing gear, or extending or retracting flaps, the reversible motor 10 is reversed, driving the hydraulic pump 30 for the limited periods of time those systems are in operation, temporarily reducing power to the aircraft air conditioning system.

In an alternative embodiment, the drive motor 10 is suitably not reversible if the clockwise over-running clutch 20 is replaced by a conventional clutch, and the counterclockwise over-running clutch 22 is similarly replaced by a conventional clutch, together with clutch controllers. The clutch controllers ensure that the appropriate clutch is engaged for the desired mode of operation and the other clutch is disengaged. That is, the clutch link to the hydraulic pump 30 is engaged when the hydraulic pump is being operated,

and the clutch linked to the air compressor 40 is engaged when the air compressor is being operated. Because in most applications the hydraulic pump is operated at a different speed than the air compressor, in this configuration, the drive motor 10 is suitably a two-speed or variable speed drive motor, but need not be reversible.

In a further alternative embodiment of the present invention, the clockwise over-running clutch 20, linked to the hydraulic pump 30, is suitably omitted if a means is provided to unload the hydraulic pump 30, such as by short circuiting the hydraulic pump, when hydraulic power is not needed or additional air compression power is needed. Similarly, the counterclockwise over-running clutch 22 is suitably omitted if a means is provided to unload the air compressor 40, such as aerodynamically unloading the air compressor by opening a large air bleed. In this embodiment, when hydraulic power is needed the air compressor 40 is unloaded, directing all of the drive motor 10 power to the hydraulic pump, and vice versa. Operating the invention without clutches, but with means to unload the hydraulic pump and the air compressor does not entail a reversible motor. However, because the hydraulic pump and air compressor are usually operated at different speeds, a dual speed, multi speed, or variable speed drive motor is suitably used.

While the preferred embodiment of the invention has been illustrated and described, as noted above, many changes can be made without departing from the spirit and scope of the invention. For example, the invention system is not limited to aircraft subsystems. It may be utilized in other vehicle or equipment applications where lightweight, simplicity, and size limitations are important. Systems other than hydraulic and air conditioning systems may be run by the dual drive. Different gearing systems may be utilized between the drive source and the shaft connecting to the over-running clutches. Rotational power may be provided indirectly, rather than directly from a motor. The freewheeling and engaging directions of the clutches may be reversed. A variable speed motor with a power electronics motor speed controller would allow the output of the air compressor and the hydraulic pump, alternatively, to be infinitely variable and controllable. Accordingly, the scope of the invention is not limited by the disclosure of the preferred embodiment. Instead, the invention should be determined entirely by reference to the claims that follow.